

Concurrent Design Approaches at JPL

*Presented
by*
Dr. Knut I. Oxnevad

at the
New Design Paradigms
Workshop

-Cross-Industrial Session-

June 26-28, 2001

Pasadena , CA, June 26 , 2001

1. Concurrent Design in Perspective

- a, The Challenge
- b, Lessons from History
- c, Back to Basics

2. Status

- a, The NPDT in a Nutshell
- b, Areas of Expertise
- c, Approach (Design Paradigm)
- d, Design and Analysis Capabilities
- e, Potential Space Shuttle Payload Application

3. Future Directions

- a, Spin-Offs
- b, HPC
- c, Concept to Hardware
- d, Concurrent Design Throughout the Organization

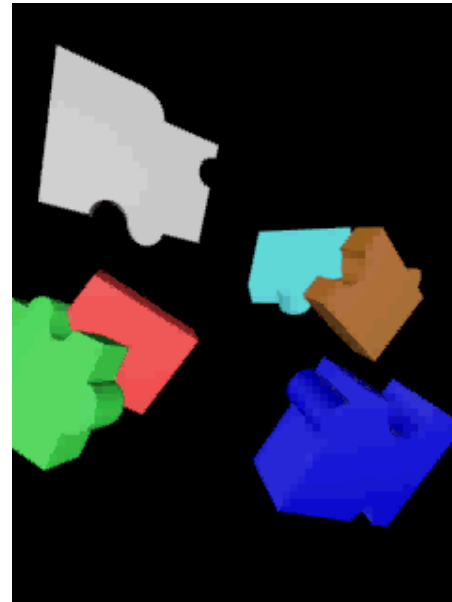
4. Conclusions & Summary

The work described in this presentation was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

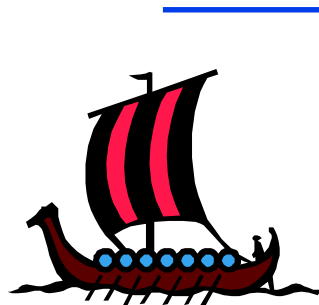
The Challenge

The biggest Challenge facing Space Development today does not lie within a specific technology, but rather in our ability to make these technologies work efficiently together to achieve our objectives.

-Knut I. Oxnevad



Lessons from History



1000

Design Complexity

Low

Basis for Design Decisions

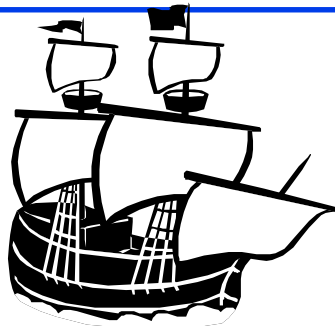
Experience

Design Collaboration



Design and Analysis Approach

- Real Time
- Working Design Session-
- Hands-On/"Touch and Feel"
- Designer and Builder the same



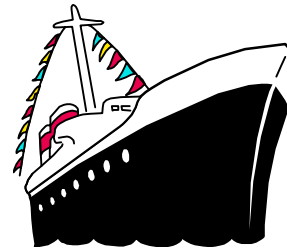
1500

Medium

Experience (H)
Computations (L)



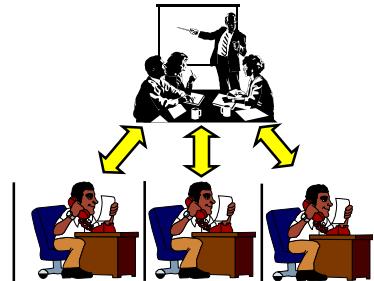
- Real Time
- Working Design Sessions
- Hands-On/"Touch and Feel"
- Designer and Builder Co-Located



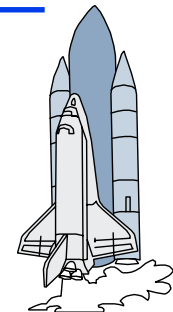
1950

High

Experience (L)
Computations (H)



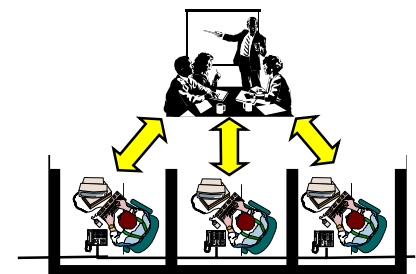
- Off-Line
- Office Work
- Meetings
- Design Reduced to Drawings and No.
- Designers and Builders Separated



1995

Very High

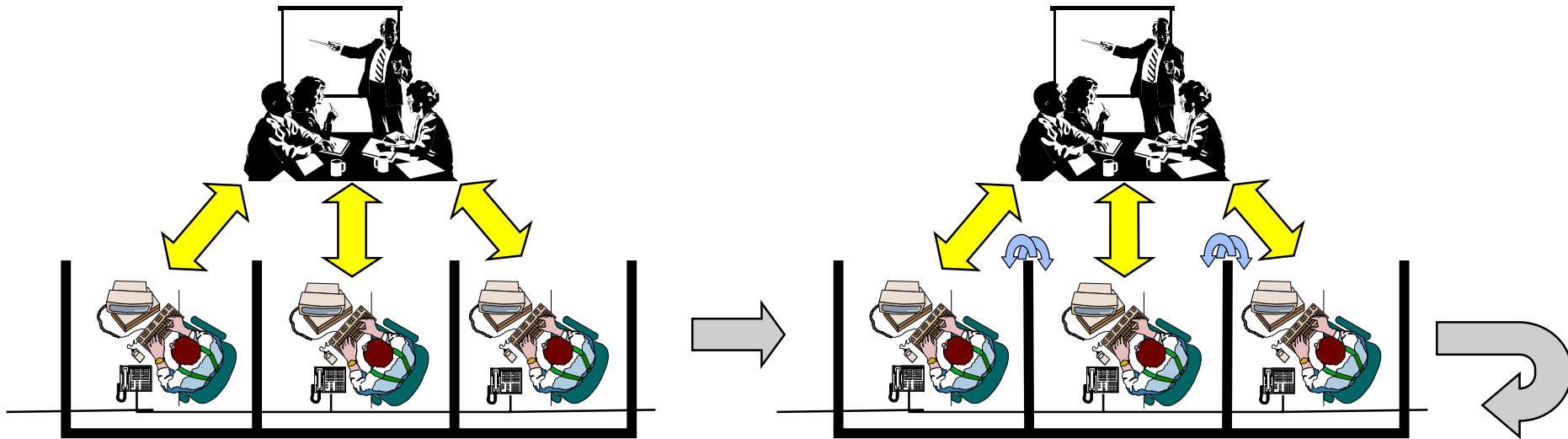
Experience (VL)
Computations (VH)



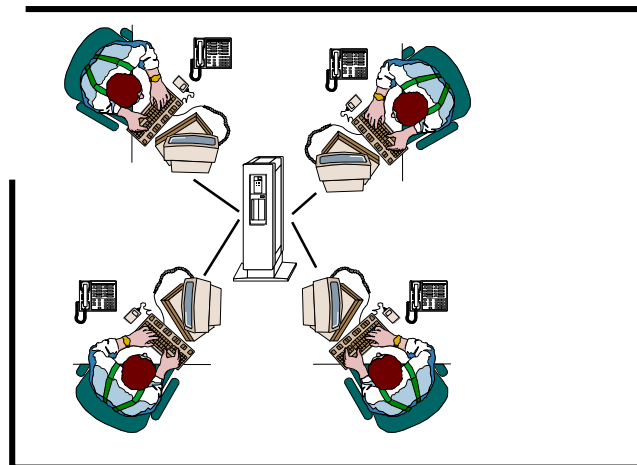
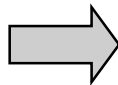
- Off-Line
- Office Work
- Meetings
- Design Reduced to Drawings and No.
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Back to Working Design Sessions

Concurrent Design



Concurrent Design



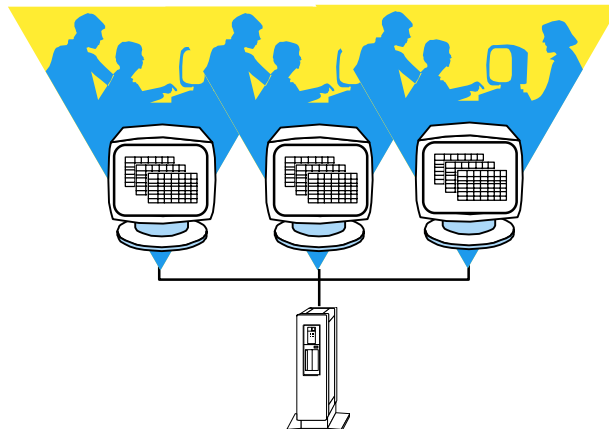
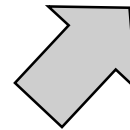
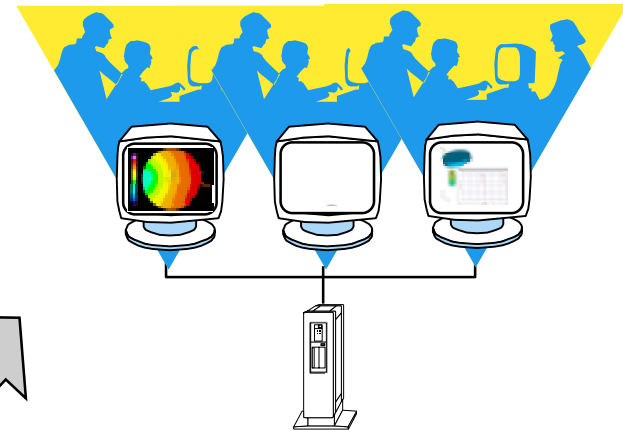
•Working Design Sessions

Back to Hands-On/"Touch and Feel"

Real Time Analysis and Design

- **Real-Time Analyses, Design, and Simulations**, using interconnected High-End SW Tools
- **Hands-On/"Touch and Feel"** from 3D representation of Design on Computer
- Powerful HW has made this approach possible
- Deliver mass, power, summaries, high-end analysis results, CAD drawings, and engineering Drawings
- Compress the full life cycle

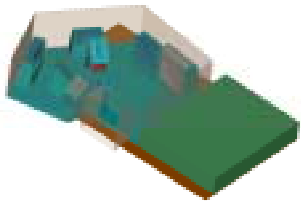
Next Generation Design Approach



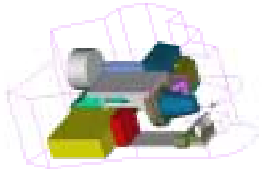
- Numerical Analyses
- Spreadsheet Based
- Mass, Power, and Cost Summaries

In A Nut Shell

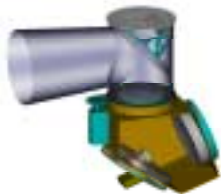
Discovery Phase 1
Gulliver



DS (ST)-4/CIRCLE

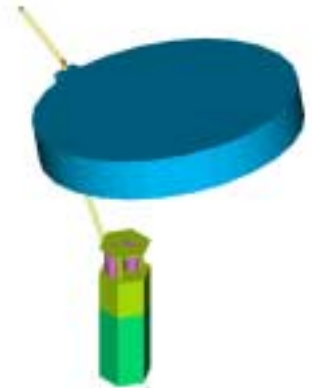


Search Camera for the
CNES Orbiter



- **Concurrent Design** and **Analysis** Environment
- **Real-Time** Analysis and Design
- Total **Systems** Approach, **Multi-Disciplinary** Team
- **Standing** Design Team
- **Customer** Actively Participates in the Design Sessions
- **Input Parameters** are **Challenged** in Real-Time
- Involved **External Experts** in the Design Sessions
- Joint Sessions with other **NASA Centers**
- From **Concept** to **Engineering Drawings**
- **Interconnected, High-End** Optical, Microwave, Mechanical/CAD , Thermal, Structural, Dynamics, Simulation, Orbital, Electronics Analysis and Design Tools, such as Code V, ZeMax, Mechanical Desktop, (Inventor), NASTRAN, Thermal Desktop, Adams, MODTool, and Working Model
- Applications Utilize a **Common** CAD Developed **Geometry**
- **Open Environment**, import/export of STEP, NASTRAN files, etc., from/to JPL, other NASA centers, and Industry
- **Technology Insertion** Through Cooperation with MDL/TAP
- Analysis and Design **Time Cut from Months to Weeks**

IIP/OSIRIS

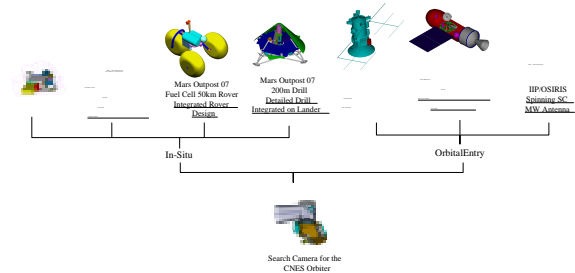
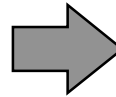


Loihi Deep Ocean,
Volcanic
Vent Probe

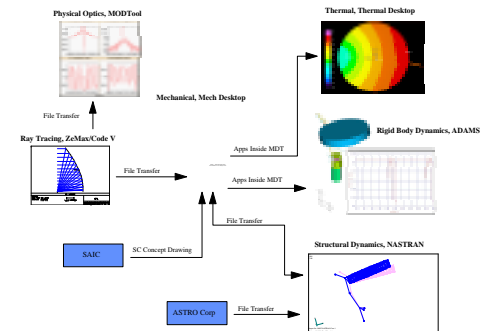
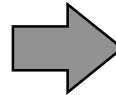


The Two Elements Expertise and Approach

1. Expertise



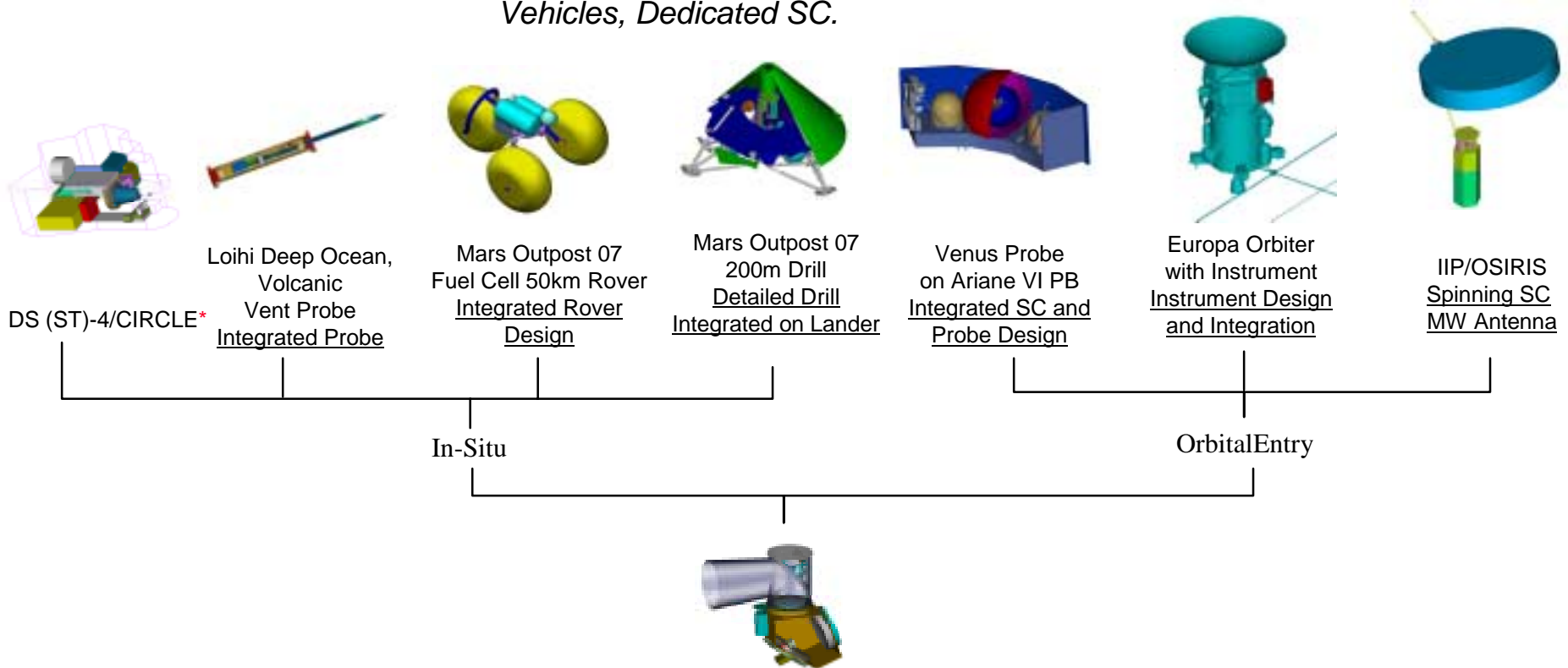
2. Approach (Design Paradigm)



Expertise

- *Expertise*

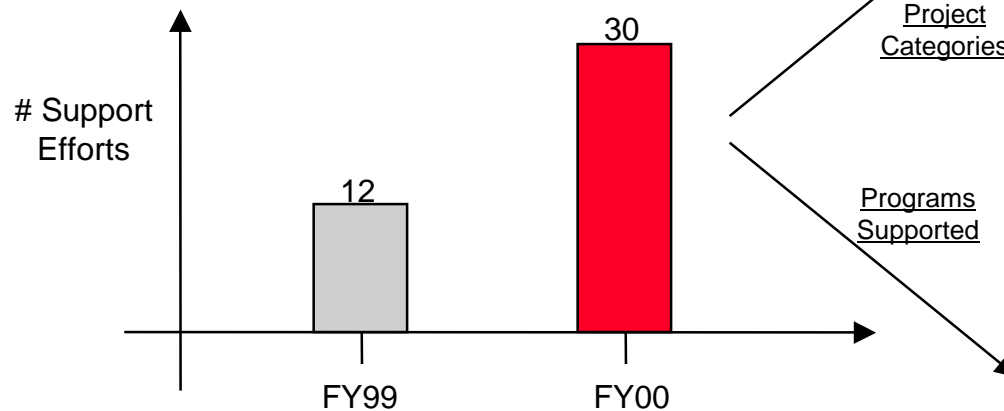
- *Synthesis, Analysis, Simulation, and Design Support*
- *Orbital and In-situ Payloads*
- *Instruments to Fully Integrated Probes/Spacecraft*
 - *Optical, Microwave, Mass Spectrometer Instruments*
 - *Surface/Subsurface Probes. Rovers, Atmospheric Entry Vehicles, Dedicated SC.*



* UV, V, and IR Systems now Handled by Instrument Team (Team I)

Search Camera for the CNES Orbiter*

Customers FY2000 Categories

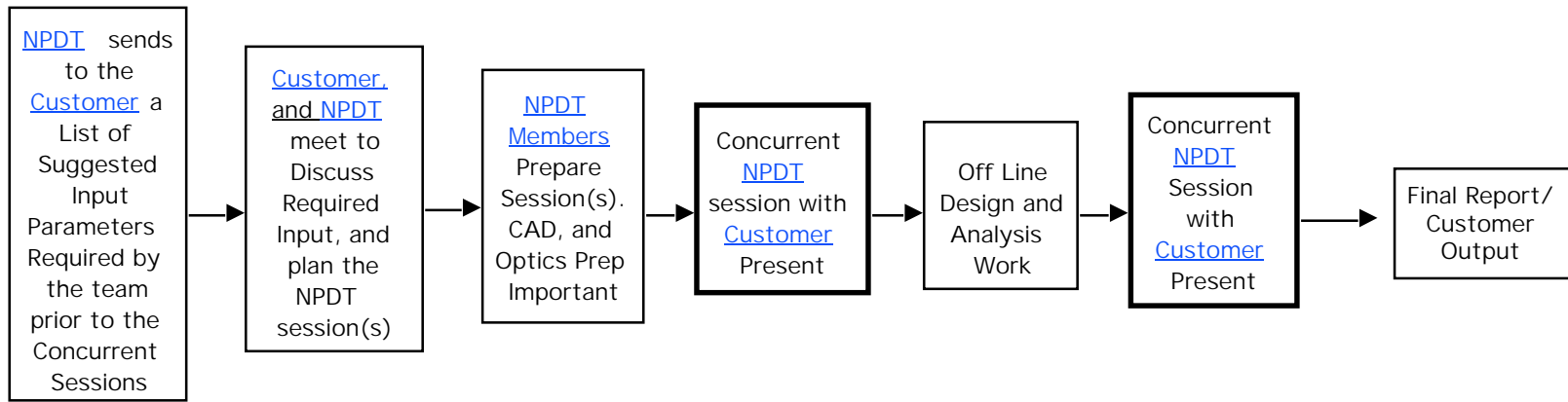


Imager/spectrometer integrated with SC/aircraft/UAV/lander/SSI/NGST: 17
 Mars descent imager integrated with lander: 1
 Hyperspectral imager integrated with SC: 3
 Imager and Radiometer integrated with probe: 1
 Telescope design: 1
 Atmospheric Entry Vehicle: 1
 Mars Lander Based Drill: 1
 Mars Rover: 2
 Mars Rover Mission (cruise, orbiter, lander, rover, and instruments): 1
 SEP launch vehicle integration: 1
 Micro/millimeter wave antenna configuration/fitting: 1

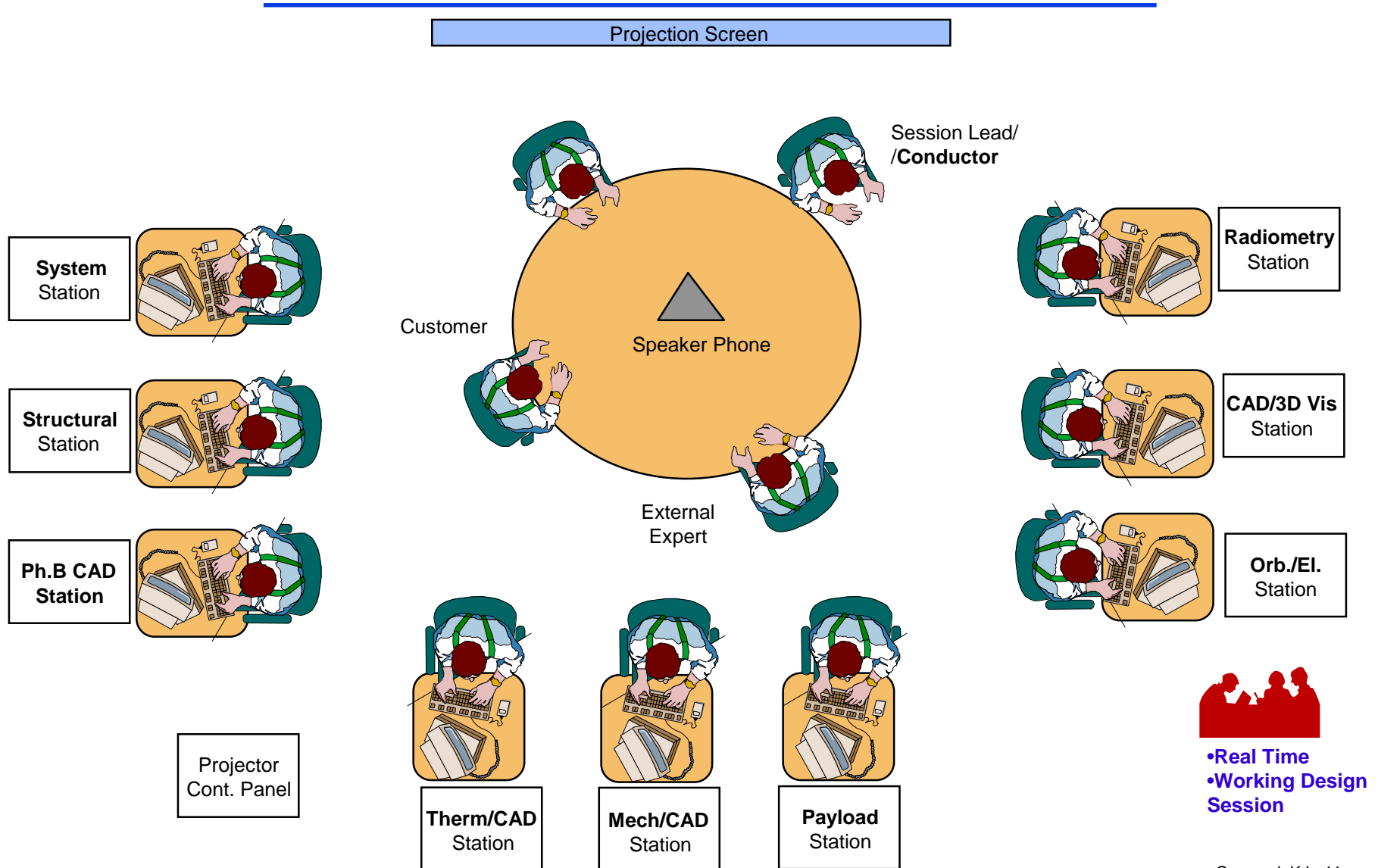
CodeY: 1
 CISSR: 1
 Discovery: 8
 Europa Orbiter: 3
 Pluto: 1
 NGST: 2
 NRA/UVA: 1
 Mars: 6
 Mars 03 Orbiter: 2
 ESSP/NGST: 2
 Space Station/UNESS: 1
 SEP: 1
 CSMAD/SURF: 1

The Lohii ocean floor volcanic vent probe developed in the NPDT was successfully taken down to 1.6 km

Overall Process

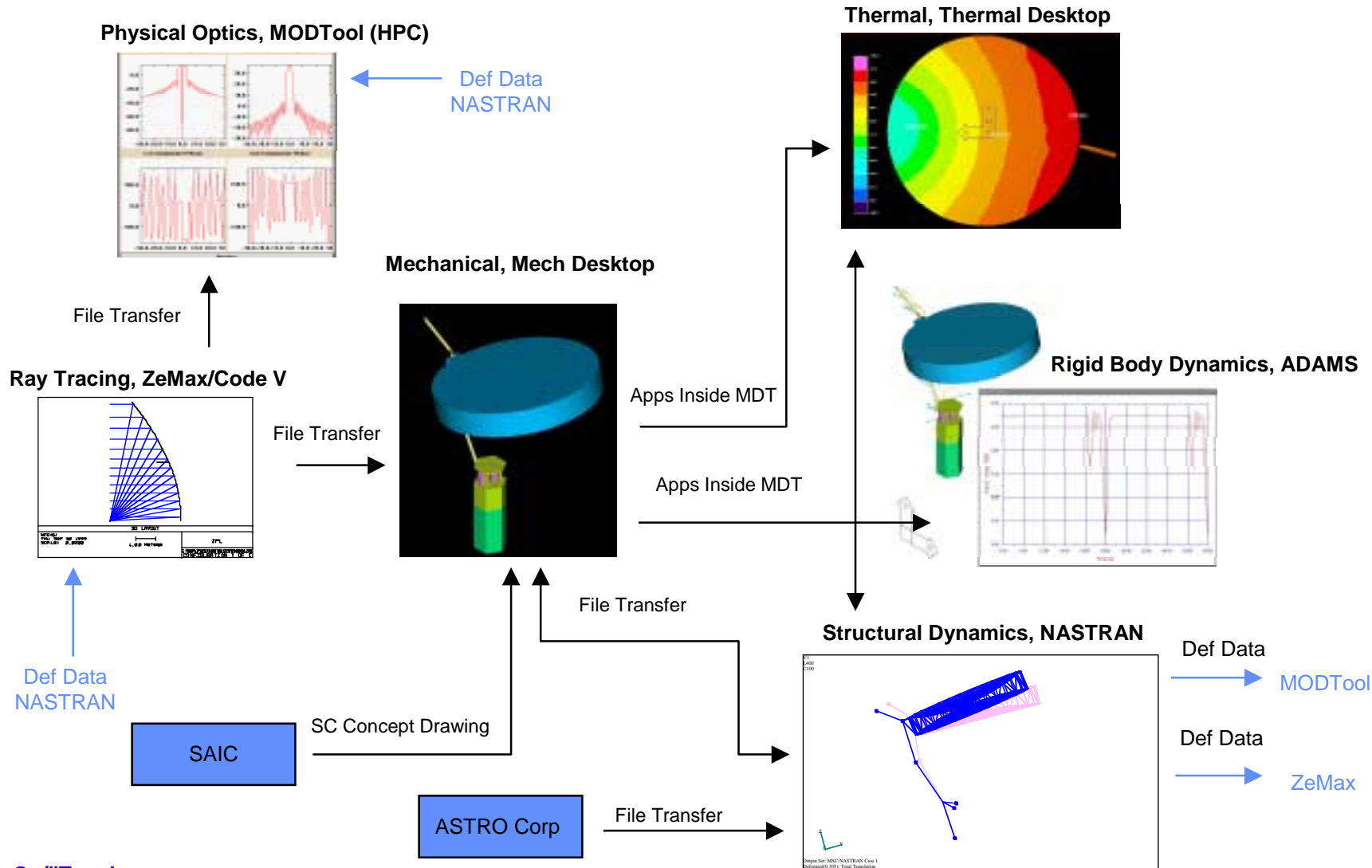


Approach Concurrent Session



**Real Time
Working Design
Session**

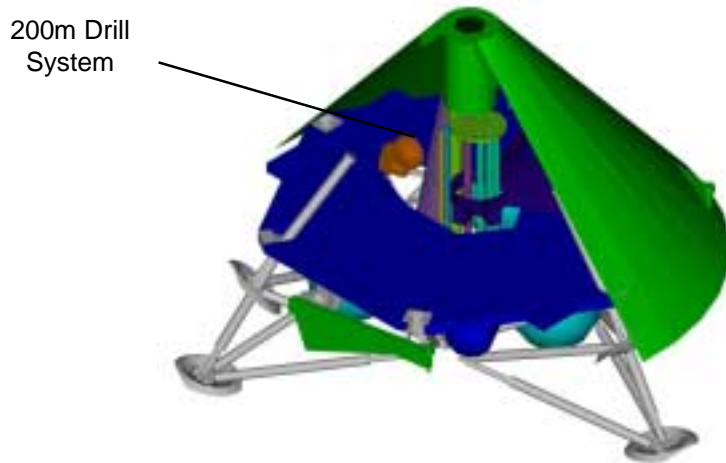
Approach (Design Paradigm): Integrated, High-End Analysis and Design



Approach

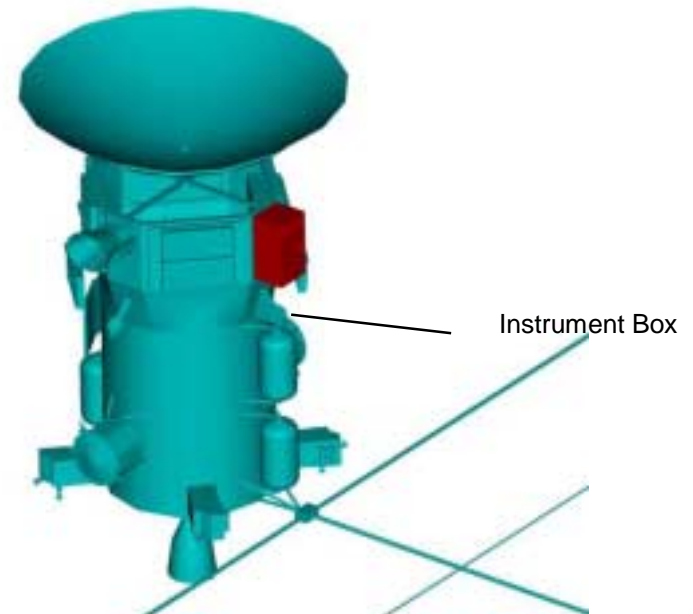
Integration of Payload and SC/ Lander

Modified 03 Lander



Support: Mechanical (parts and assemblies),
Assembly simulation, Mass, and Cost

Europa Orbiter

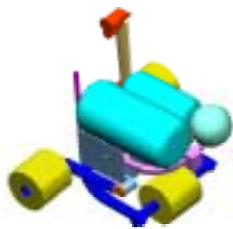


Support: Mechanical (parts and assemblies), Optics,
Electronics, Orbital, Thermal, Mass, Power, and Cost

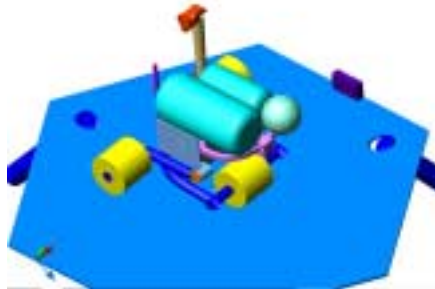
Approach

Sizing, Configuration, and Simulation

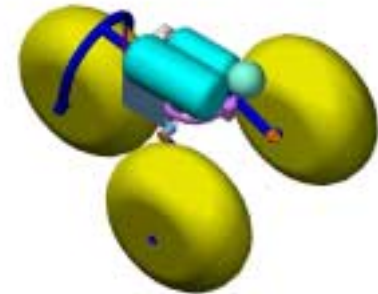
Mars Outpost *50km Fuel Cell Rover*



Lander Configuration



Deployment Sequence

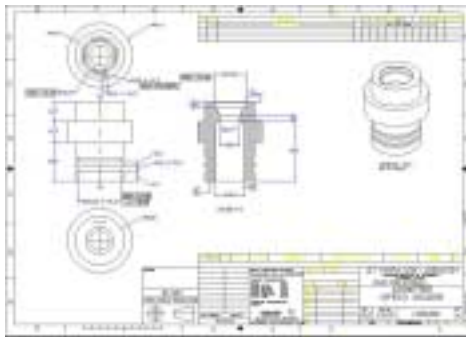


Surface Configuration

Support: Mechanical (parts and assemblies), Structural, Surface Mobility/Ops Simulations, Trade Studies, Mass Summary

Approach

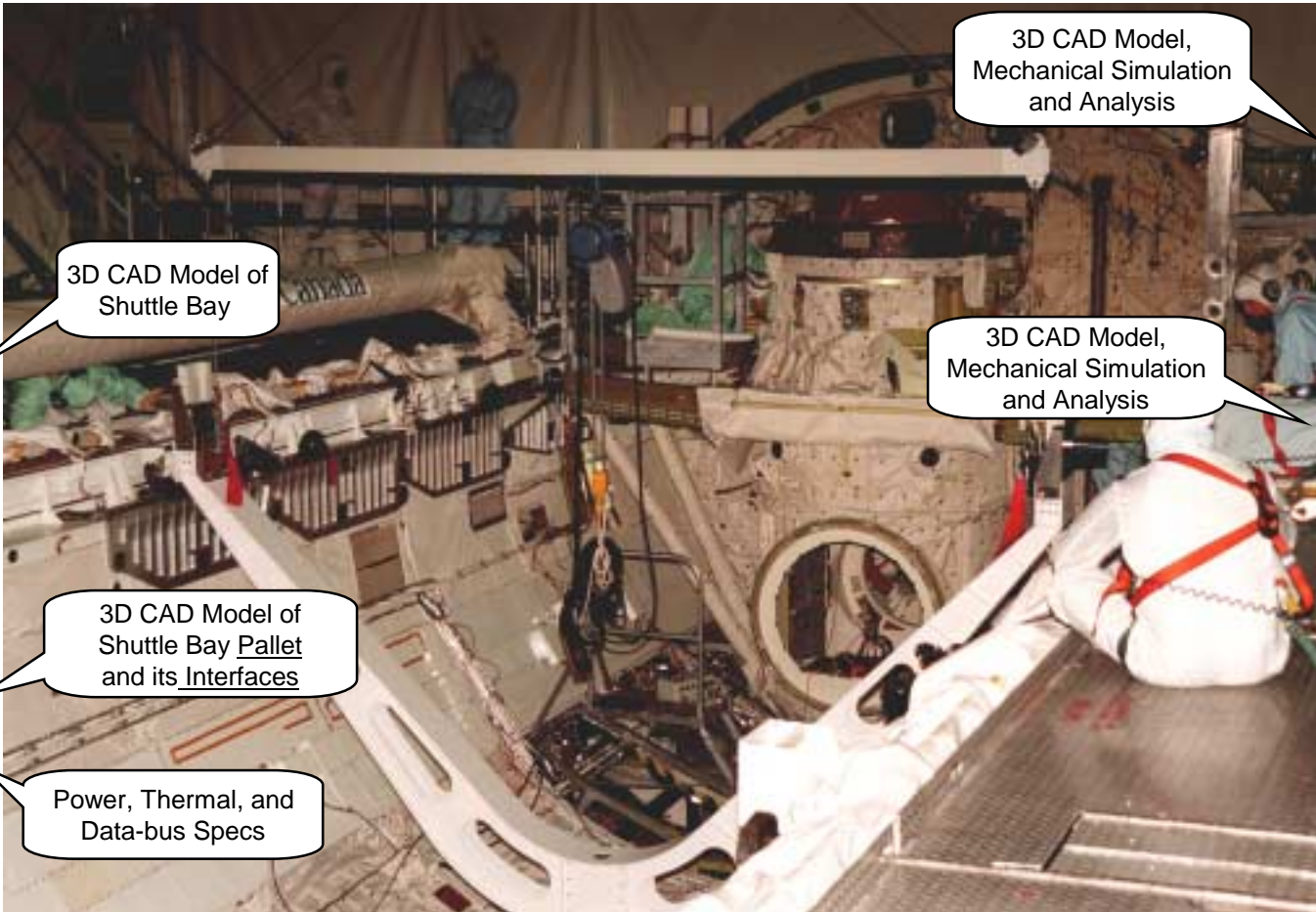
Concept, Hardware, Science Data



Support: Mechanical (parts and assemblies), Structural, Electronics, Optics, and Engineering Drawings

Space Shuttle Bay Payload Integration

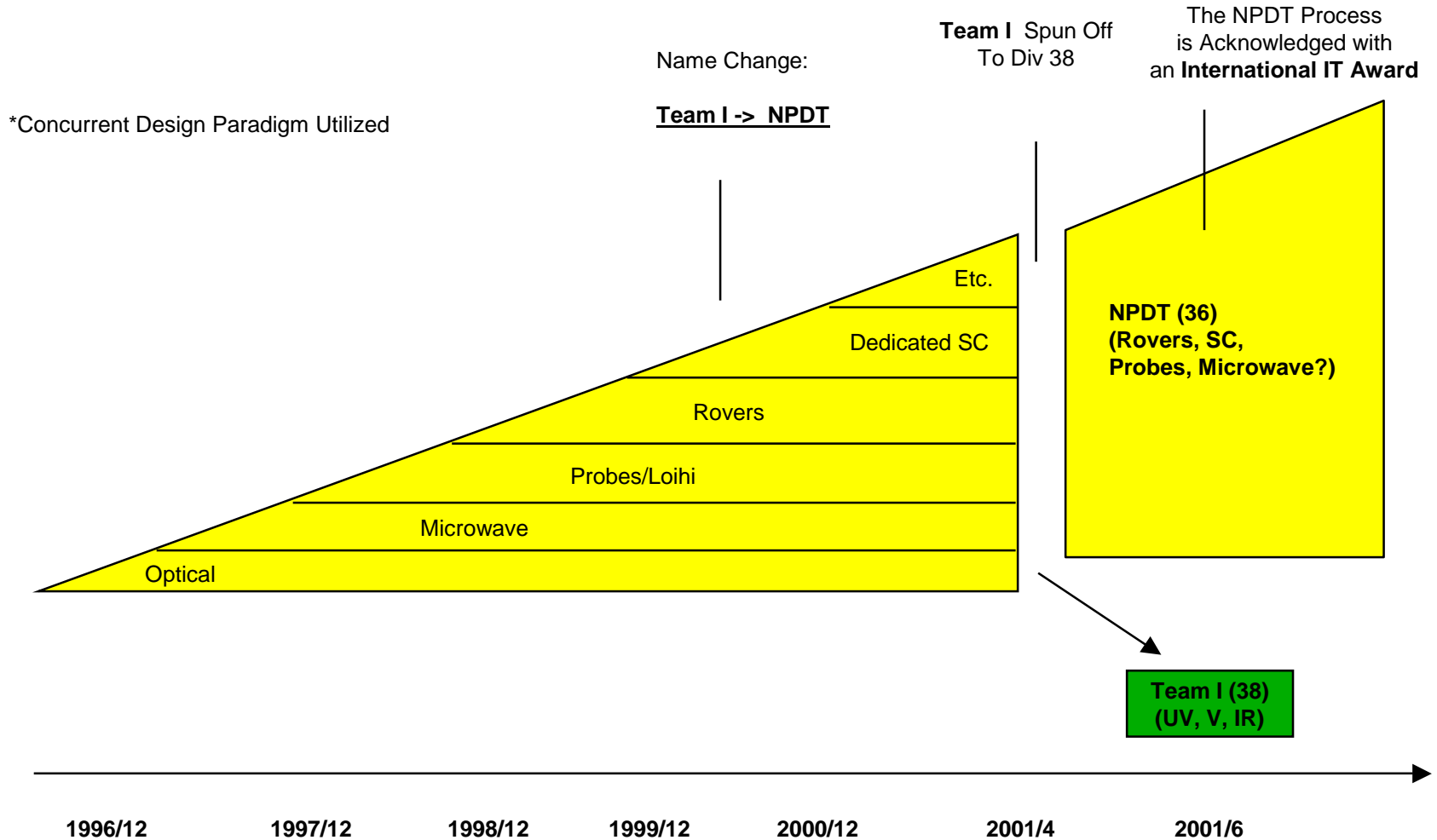
A Potential Application



Placement and Installation of Payload in Bay:
Crane Reach and Capacity, People Reach and Limitations

Pay Load Deployment:
Shuttle and SSI Robotic Arm Interfaces, and Movement Constraints, CG, SSI Interfaces

Future Directions Past to Future



Future Directions

Main Issues

- Set up a new Design Center - the **Concurrent Design Laboratory**
- R&D efforts**
 - Improving the efficiency of existing design teams
 - Developing An Art to Part Design Process for space vehicles
 - STEP interfacing
 - Better Utilization of COTS tools in the Modeling and Simulation Areas
 - Use of HPC (supercomputers, parallel computing systems)
 - CFD, Thermal, Structural)
 - Utilization of Concurrent Design Teams throughout the Design Process
- Defining training, and **setting up new Design Teams** (JPL, NASA centers, industry, and academia)
- Set up **Workshops** to Bring Focus on New Design Paradigms
- Set up Working **Relationships with Academic Organizations**/Initiate Research
 - Caltech (SURF, on-going)
 - International Space University (ISU)
 - MIT, Stanford, University of Irvine California, Pasadena Art Center, University of Southern California (TBD)
- Be a **Resource Center for JPL** in the Areas of New Design Approaches
- Utilize concurrent design teams throughout the organization**